The object of the study is the processes of financial, credit and budgetary support for the modernization of the aerospace complex based on the transfer of modern technologies. The problem of strategic innovation principles for the modernization of the aerospace complex is solved in order to preserve the scientific and technical potential of the state, strengthen the defense capability and increase the export potential of highly intelligent products.

According to the results of statistical research, the achievements and problems of the modernization of the national economy and the aerospace complex of Ukraine based on the transfer of modern technologies during 2015–2023 were diagnosed. By industry, an increase in the volume of capital investments in cargo aerospace transport by 1050.9 million UAH, or by 435.7%. It is shown that the volume of capital investments in passenger aviation transport decreased by 962.1 million UAH, or by 74.78%. Structural changes are associated with a reduction in the share of passenger air transport from 84.21% to 20.07% against the background of an increase in the share of air cargo and space transport. By object, an increase in the share of software and databases from 26.7% to 62.44% was diagnosed.

The features of the study are the use of a synergistic approach between the interaction of financial, credit, and budgetary instruments in the interests of ensuring cluster development of the aerospace industry. The scope of the results obtained is their implementation in the activities of international organizations, state and local governments, business entities, collective and individual investors to ensure the transfer of modern technologies for the modernization of the aerospace complex.

The conditions for the practical use of the research results are the formation of a modern technology transfer infrastructure

Keywords: provision, financial, credit, budgetary, business entities, aerospace, transport, transfer, technologies, innovations

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FINANCIAL, CREDIT AND BUDGETARY SUPPORT FOR THE TRANSFER OF MODERN TECHNOLOGIES FOR THE MODERNIZATION OF THE AEROSPACE COMPLEX

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1. Introduction

In the current conditions of active development of the world market of high-tech products and increased competition between leading countries in the field of aerospace activities, the modernization of the material and technical base is of particular importance. In the field of aerospace complex (ASC), borrowing and transfer of advanced technologies play an important role. At the same time, the practical implementation of the latest technological solutions is impossible without adequate mechanisms of financial, credit and budgetary support. That is why the study of sources and tools for supporting technology transfer in ASC is extremely relevant both in theoretical and applied dimensions.

For Ukraine, this topic is of particularly high importance, since the aerospace complex is traditionally one of the key strategic sectors of the national economy, but its material and technical base requires immediate renewal and modernization. The conditions of martial law, the growth of external technological isolation and the limitation of its own investment resources significantly complicate the process of updating the production infrastructure. However, it requires the involvement of budgetary, credit and grant support mechanisms, including through international financial organizations and technology transfer programs.

The most problematic issues in the use of technology transfer in Ukraine are insufficient financing of innovative activities, weak relationships between scientists and practitioners, lack of interest of researchers in promoting developments, imperfect state regulation and patent and licensing support, etc. In this regard, the study of financial, credit and

budgetary support for the modernization of the aerospace complex based on the transfer of modern technologies acquires special scientific and practical significance. It allows formulating recommendations on the optimal use of state support mechanisms, international financing, public-private partnership instruments and the development of national technology transfer policy.

Therefore, the study devoted to the financial, credit and budgetary support for the modernization of the aerospace complex based on the transfer of modern technologies is relevant in view of the existing dilemma. On the one hand, under martial law, the ASC role in the system of ensuring the country's defense capability is increasing, on the other hand, there are restrictions on the use of airspace, as well as difficulties with financing, lending, and budgeting of business entities in the industry.

2. Literature review and problem statement

In [1], a review of literature sources was conducted and the current state of technology transfer issues was diagnosed, as well as the content of concepts and models based on the flow of knowledge was summarized. In [2], the results of a study of technology transfer used during the construction of scientific satellites were presented; the mechanisms for implementing space technology transfer in practical activities were specified. Proposals were developed for the integration of technical processes in industrial sectors of the economy from the point of view of significantly strengthening and increasing productivity in the aerospace complex. However, the presented results require adaptation to the institutional conditions of the industry.

In [3], an assessment of technology transfer processes was conducted in the context of innovative economic development and measures were developed to improve them. The authors considered the economic essence, the significance of technology transfer and the features of its use; outlined the features of effective technology transfer in Ukrainian practice and in developed countries; presented a new toolbox aimed at activating technology transfer in Ukraine. However, issues related to technology transfer in the ASC remained unresolved. The reason for this may be the restrictions on the implementation of operational activities of industry entities under martial law.

An option for overcoming the relevant difficulties may be the innovation and investment renewal of the ASC. This is the approach used in the work [4], which examines the problems of technology transfer in aerospace programs in the form of an autopilot. However, the implementation of the developed recommendations requires the modernization of mechanical engineering enterprises that produce aircraft and spacecraft.

The application of fuzzy-set qualitative comparative analysis (fsQCA) to a sample of firms in European aerospace clusters [5] allowed to explain the results of innovations. They are based on a combination of internal assets and external resources provided by geography, networks and institutions. At the same time, the emphasis is placed on the fact that no single resource is sufficient on its own. Given the effectiveness of the cluster approach in the EU, it is necessary to adapt the specified experience to the institutional conditions of the functioning of the domestic ASC due to limited resources.

The authors of the work [6], based on a literature review and direct observations, highlighted the issues of developing a model of strategic management of technological innovations in scientific and technical institutions. It has management tools that improve the proactive activities of ecosystem agents and help them transfer and assimilate developed technologies. It was determined that the proposed management model can be applied in any national or international ecosystem of technological innovations, while maintaining the characteristics of the business environment. Despite the convincing conclusions, the issues of the cost part of the implementation of technology transfer remain undeveloped.

The work [7] contributes to understanding the evolution of the aerospace complex and the role played in this process by innovation policy and industrial changes. It examines the impact of business-government interaction on the development of the industry by creating national agencies to support it through innovation policy instruments, along with the privatization and consolidation of aerospace enterprises. However, the authors do not provide an assessment of the level of monopolization of ASCs and proposals for demonopolization at the level of specific business entities.

Based on previous studies of joint research enterprises for EU subsidies in the aerospace complex, work [8] puts forward and tests a number of hypotheses for assessing the effectiveness of project financing. The fundamental impossibility of using the developed recommendations in the conditions of Ukraine is determined by the limited budget resources for financing the ASC due to their reorientation to defense needs.

In work [9], a sectoral analysis of economic development based on the theoretical principles of the correlation of the concepts of ownership-location-internalization was applied to the activities of multinational enterprises in the aerospace complex. However, issues related to increasing the competitiveness of national airlines in the foreign air traffic market remained unresolved.

The object of research in work [10] is the processes of innovative and financial modernization of the transport complex based on international technology transfer. The authors solved the problem of strategic innovative principles for strengthening its competitiveness in the conditions of integration into the EU. The ideas outlined require further development in terms of implementing European standards for the activities of business entities of the domestic ASC.

The paper [11] considers the problem of formation, transfer and implementation of high technologies of the aviation profile based on the methodology of convergence of comprehensive programs for the innovative development of aviation enterprises. However, the approaches to program-targeted financing of ASC need to be clarified. The current organizational and legal form of technology transfer networks in the aerospace industry is contractual with the conclusion of agreements on joint activities for the purpose of implementing a joint project [12]. At the current stage of development of economic relations, a modification of consortium agreements has taken place, which take into account the tasks, functions and features of the activities of technology transfer networks and the main object of relations between its participants, represented by information. However, it should be noted that the value of the study would increase if the prospects for consortium lending for technology transfer projects in ASC were determined.

Unresolved problems in the studied area are reduced to the contradiction between the awareness of the importance of innovative development of the aerospace industry and the lack of funds for the use of technology transfer, which is its basis. All this gives grounds to argue that it is advisable to

conduct a study devoted to financing, lending, budgeting of technology transfer in the ASC on the basis of innovation.

3. The aim and objectives of the study

The aim of the study is to improve the financial, credit and budgetary support for the modernization of the aerospace complex based on the transfer of modern technologies in conditions of risk and uncertainty based on innovations and leading foreign experience. This will make it possible to activate the role of the industry as a driver of ensuring national security and stimulating the development of the economy in general and certain related activities.

To achieve the aim, the following objectives were set:

– to determine the content, purpose, key principles of the modernization of the aerospace industry based on technology transfer;

– to establish the principles of an effective system of financial and credit support for technology transfer in the aerospace complex;

– to determine the differential features of budgetary support for technology transfer in the aerospace complex;

– to generalize the European and American experience of financial, credit and budgetary support for the development of the aerospace complex, including within the framework of international defense alliances;

– to diagnose the problems of the modernization of the Ukrainian aerospace complex based on the transfer of modern technologies and to propose ways to solve them.

4. Materials and methods

The object of the study is the processes of financial, credit and budgetary support for the modernization of the aerospace complex based on the transfer of modern technologies. The main hypothesis of the study is that the effectiveness of financial, credit and budgetary support for enterprises of the aerospace complex of Ukraine is quantitatively determined by the volume of available resources. Also important are qualitative factors related to their structuring, targeting innovative areas, in particular through mechanisms of technology transfer, public-private partnership and integration into international programs. The study assumes that the main factors of the effectiveness of financing, crediting and budgeting of enterprises of the aerospace complex of Ukraine are the quality of resource structuring and targeting them in innovative areas. It is achieved by the functioning of mechanisms of technology transfer and public-private partnership; determining the proportions of the distribution of funds between R&D (scientific research and development work), modernization of the material and technical base, attracting private capital, etc. The idea of synergy of public and private financing, transfer of modern technologies as a key mechanism for increasing the competitiveness of ASC enterprises, introduction of adaptive financial and credit and budgetary instruments for their financing is important.

Alternative (working) hypotheses of financial and credit and budgetary support for the ASC development are:

– hypothesis of lack of resources, which hinders the modernization of the material and technical base and reduces competitiveness in the world market;

– hypothesis of external dependence on foreign financing and international programs. which creates risks of financial and technological security;

– hypothesis of institutional inefficiency of financial resources, which is due to shortcomings in budget planning, bureaucracy and weak coordination between the state and business;

– hypothesis of the military factor, since the full-scale invasion of the Russian Federation in 2022 into Ukraine became a catalyst for changing the structure of ASC financing with a shift in the preferences of budget financing towards private and international investments, as well as the transfer of defense technologies;

– the hypothesis of an innovative breakthrough in the conditions of limited ASC resources, which is based on the fact that funding will be directed to innovative areas (unmanned systems, new materials, dual-purpose space technologies).

The research materials are formed by the regulatory framework of Ukraine, official statistical materials of the State Statistics Service of Ukraine "Statistical Yearbook of Ukraine – 2023" [13], "Transport of Ukraine – 2023" [14], as well as online resources. An important source of information is also the scientific and analytical report of the State Scientific Institution "Ukrainian Institute of Scientific and Technical Expertise and Information" "Scientific, scientific and technical and innovative activity in Ukraine in 2023" [15]. The research process used systemic and socio-technical approaches; general scientific methods of analysis and synthesis, systematization, construction of analytical tables, assessment and diagnostics, formalization of trends; the "5M" method (Machines, Manpower, Materials, Methods, Money).

5. Results of research on financing, lending, budgeting of technology transfer in the aerospace complex

5. 1. Content, purpose, key principles of modernization of the aerospace industry based on technology transfer

Technology transfer is the process of transferring knowledge, research results and innovations from one organization or country to another for their further commercialization. Technologies can take various forms, from the development of complex electronics to the application of basic procedural principles. The main tools for their transfer are the exchange of technological principles between the areas of technology application. Technology transfer is closely related to intangible assets (IA), which do not have a physical form, but have economic value. The main objects of IA are: intellectual property (patents, copyrights, trademarks, industrial designs); know-how (technological solutions, methods, unique knowledge); software; business reputation (goodwill). Most technologies are protected as IA (patents, licenses, know-how), and it is through these instruments that their transfer occurs on the basis of concluding a license agreement. Technology transfer is impossible without a correct assessment of intangible assets, because they form the price of the transaction. IA is the basis of technology transfer, and the transfer acts as a mechanism for realizing their value in business and society, as well as a driver for creating new products and services.

Table 1 shows the dynamics of investments in intangible assets, their components and structure in the national economy.

During 2015–2023, the value of investments in intangible assets in the national economy increased by 12,438 million UAH, or by 67.65%, primarily due to software and databases – by 14,338 million UAH, or 292.14%. However, rights to commercial designations, industrial property objects, copyright and related rights, patents, licenses, concessions, etc. decreased by 8,034 million UAH, or by 63.49%. As a result of the above dynamics, the share of software and databases increased from 26.7% to 62.44%, or by 35.74%. The share of rights to commercial designations, industrial property objects, copyright and related rights, patents, licenses, concessions, etc. decreased by 68.83% to 14.99%, or by 53.84%.

The dynamics of the cost of software and databases is described by the ascending branch of the parabola (1), and other IAs by the descending branch of the parabola (2):

$$y = -112.51x^2 + 2{,}974.3x + 2{,}737.9,\ R^2 = 0.8918, \quad (1)$$

$$y = 113.27x^2 - 3{,}358.4x + 20847,\ R^2 = 0.5498. \quad (2)$$

To construct the above equations, data in natural terms (million UAH) were used, presented in Table 1. They are built in the EXCEL environment using the "Setting a line chart" and "Trend selection" options.

Overcoming negative trends in the ASC should be based on its modernization as a systemic process of updating production facilities, introducing advanced technologies, improving the technical level of the material and technical base and organizational and management mechanisms. The purpose of modernization is to ensure competitiveness, scientific and technical independence and integration into global aerospace value chains. It involves updating equipment, digital transformation of production, development of new types of products, compliance with safety and environmental requirements, as well as integration of the results of the military and civilian sectors through technology transfer mechanisms.

During 2018–2023, the cost of capital investments in the ASC changed chaotically, but overall increased by 88.8 million UAH, or 5.81% (Table 2).

Data on the volume of capital investments in the ASC industry in 2022 have been made public, but by its types are confidential information. Therefore, to eliminate gaps in the analysis of the flow of processes, three iterations were performed. The first concerned the calculation of the arithmetic mean value according to the data of 2021 and 2023, determining their amount. The second involved the calculation of the adjustment coefficient as the ratio of the actual volume of investments in ASC in 2022 to the amount determined based on the results of the previous operation. As a result of the third iteration, extrapolated values of the volume of capital investments by ASC sub-industries were obtained as the product of the arithmetic mean indicators determined based on the results of the first iteration and the adjustment coefficient.

The volume of capital investments in passenger air transport decreased by UAH 962.1 million, or by 74.78%. However, capital investments in cargo air transport and space transport increased by 1,050.9 million UAH, or 435.7%. The above dynamics led to significant structural changes, as a result of which the share of passenger air transport decreased from 84.21% to 20.07%, and the share of air and space transport increased from 15.79% to 79.93%.

Table 1

Indicators of the dynamics of investments in intangible assets, their components and structure in the national economy

Indicator	2015	2018	2019	2020	2021	2022	2023	Absolute growth
Million UAH								
Investments in intangible assets:	18,385	36,391	23,411	24,893	31,098	20,618	30,823	12,438
Of which software and databases	4,908	9,476	10,215	12,411	16,644	13,793	19,246	14,338
Rights to commercial designations, industrial property objects, copyright and related rights, patents, licenses, concessions, etc.	12,654	24,382	8,389	8,389	6,044	3,274	4,620	–8,034
Structure, %								
Investments in intangible assets:	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0
Of which software and databases	26.70	26.04	43.63	49.86	53.52	66.90	62.44	35.74
Rights to commercial designations, industrial property objects, copyright and related rights, patents, licenses, concessions, etc.	68.83	67.00	35.83	33.70	19.44	15.88	14.99	–53.84
Official exchange rate of the national currency, UAH/USD								
As of the end of the year	24.0	27.68	23.68	28.27	27.27	36.56	37.98	13.98

Table 2

Analysis of the dynamics and structure of capital investments in ASC

Type of transport	CEA code	2018	2019	2020	2021	2022	2023	Absolute growth
mullion UAH								
Aerospace transport	51	1527.7	1767.9	856.2	1598.0	685.6	1616.5	88.8
Passenger aviation transport	51.1	1286.5	1324.7	504.5	49.5	101.9	324.4	–962.1
Cargo aviation transport and space transport	51.2	241.2	443.2	351.8	848.5	583.7	1292.1	1050.9
Structure, %								
Aviation transport	51	100	100	100	100	100	100	0
Passenger aviation transport	51.1	84.21	74.93	58.92	3.10	14.87	20.07	–64.14
Cargo aviation transport and space transport	51.2	15.79	25.07	41.09	53.10	85.13	79.93	64.14

The transfer of technologies and other objects of intellectual property rights in the ASC field is carried out by a number of entities. Among them: higher education institutions, scientific institutions that fall under the jurisdiction of the Ministry of Education and Science of Ukraine (MES), the National Academy of Sciences of Ukraine (NAS), other enterprises and organizations. During 2019 2023, the largest number of technology transfer agreements in the national economy was concluded in 2021 – 1,862 agreements, and in 2022 and 2023 their number decreased significantly. In 2023, 1,322 agreements were concluded for a total amount of 107.13 million UAH, which is 1.13 million UAH more than in 2022. In the areas of development of innovative activity and technology transfer, the largest share of funds in 2023 was used to assess the scientific and technical level of technologies and/or their components as an object of commercialization – 33.20 million UAH, which is 26.5% more compared to the indicator in 2022. Giving preference to this particular direction of using funds indicates that technology developers understand the importance of market research and the desire to increase the competitiveness of their technologies.

Table 4 presents the results of the analysis of credit risk of banking institutions based on the amount of exposure at risk for loans granted to economic entities of the Ukrainian ASC.

Table 3

Balances of funds under loans granted to business entities of the aerospace complex of Ukraine as of 01.07.2025 and their structure

CEA section	Total loan portfolio, million UAH			Horizontal structure, %			Vertical structure, %		
	Total	NC	FC	Total	NC	FC	Total	NC	FC
Large enterprises									
51	638.2	10.3	627.9	100	1.61	98.39	3.86	0.11	8.31
52	3,415.6	3,375.8	39.7	100	98.83	1.16	20.66	37.60	0.53
Medium enterprises									
52	9,640.9	4,332.2	5,308.7	100	44.94	55.06	58.30	48.26	70.23
Small enterprises									
52	2,413.0	840.8	1,572.2	100	34.84	65.16	14.59	9.37	20.80
Microenterprises									
52	428.2	418.0	10.2	100	97.62	2.38	2.59	4.66	0.13
Total	16,535.9	8,977.1	7,558.7	100	54.29	45.71	100	100	100

Table 4

The amount of exposure at risk for loans granted to economic entities of the Ukrainian Aerospace Industry as of 01.07.2025 and its structure

CEA section	Total loan portfolio, million UAH			Horizontal structure, %			Vertical structure, %		
	Total	NC	FC	Total	NC	FC	Total	NC	FC
Large enterprises									
51	635.9	10.3	625.6	100	1.62	98.38	3.77	0.11	7.93
52	3,422.1	3,382.0	40.1	100	98.83	1.17	20.28	37.62	0.51
Medium enterprises									
52	9,763.1	4,334.9	5,428.3	100	44.40	55.60	57.84	48.22	68.81
Small enterprises									
52	2,626.9	842.2	1,784.7	100	32.06	67.94	15.56	9.37	22.62
Microenterprises									
52	430.3	420.2	10.2	100	97.65	2.37	2.55	4.67	0.13
Total	16,878.3	8,989.6	7,888.9	100	53.26	46.74	100	100	100

5. 2. Principles of an effective system of financial and credit support for technology transfer in the aerospace complex

A statistical study of credit support for ASC (Table 3) was conducted using the CEA (Classification of Economic Activities) codes 51 and 52. They combine passenger, cargo and space transport, as well as warehousing and auxiliary activities in the transport sector, primarily airports, based on data from the National Bank of Ukraine [16].

In Table 3, the following designations are adopted:

– NC – national currency;

– FC – foreign currencies provided for by the NBU Foreign Currency Classifier, in hryvnia equivalent.

The greatest opportunities for financing technology transfer through borrowed funds are available to large, micro and small enterprises of the ASC, since the share of defaulted loans is 1.61%, 3.34%, 11.68%, respectively. Large enterprises receive loans mainly in foreign currency, the share of which is 98.39%. The worst opportunities for financing technology transfer through borrowed funds are available to medium-sized enterprises with a specific weight of defaulted loans in the amount of 78.1%. This determines the high level of credit risk in the industry at 47.39%, since according to the results of the vertical analysis of the loan portfolio, defaulted loans of medium-sized enterprises account for 96.09%. In the structure of the credit portfolio of small and medium-sized enterprises, foreign currency loans also prevail, the share of which is 67.94% and 55.60%, respectively.

According to the results of the horizontal analysis, it was found that the largest share in foreign currency falls on large road transport enterprises (98.38%), small enterprises (67.94%), medium-sized enterprises (55.60%). On average, the share of exposure under risk for foreign currency loans is 46.74%. According to the results of the vertical analysis, it was determined that the prevailing influence in the national currency is exerted by medium-sized enterprises (48.22%) and large enterprises (37.62%), and in foreign currency – by medium-sized enterprises (68.81%).

5. 3. Differential features of budgetary support for technology transfer in the aerospace complex

Effective implementation of technology transfer in the ASC is impossible without comprehensive financial support, which combines budgetary resources, credit instruments and public-private partnership (PPP) mechanisms. Each of these components plays its own role in ensuring the modernization of the material and technical base, the development of innovative technologies and the integration of scientific developments into industrial production.

Financial support for technology transfer in the ASC is based on a combination of budgetary, credit, investment and grant resources aimed at accelerating the implementation of innovations and the development of new products. The

main sources of financing for technology transfer in the ASC are: the State Budget of Ukraine and local budgets of Ukraine (programs for the modernization of the defense-industrial complex, grant programs of space agencies, state support for innovations). Financial and credit instruments are represented by preferential lending, state guarantees, interest rate compensation programs, the activities of export credit agencies, own investment programs of enterprises and venture capital for startups in the field of aerospace technologies. In modern conditions, the capital intensity of space and aviation technologies, the long duration of R&D and the riskiness of innovations make this process practically impossible without attracting state-specific funding or PPP instruments. An important role is played by special-purpose funds and international programs (NASA SBIR/STTR, ESA Technology Transfer Programme, Horizon Europe), the European Defense Fund EDF (European Defense Fund). EDF is a program that finances scientific research and modernization in the defense and space sectors of the EU, including technology transfer instruments.

Technology transfer financing can also be provided through mechanisms for sharing infrastructure, R&D hubs, clusters, which allows reducing the financial burden on individual enterprises due to the effect of scale. For example, in the budget structure of NASA, ESA, and the US Department of Defense in 2021–2025, special items are allocated for the Technology Transfer and Commercialization program, which allows not only to create new technological solutions, but also to ensure their transfer to small and medium-sized companies for industrial use.

Credit support for technology transfer in the aerospace complex plays the role of a catalyst for enterprises to access the necessary investment resources to finance technological solutions and equipment modernization. Given the high capital intensity and long payback period of innovative projects, the use of traditional bank loans is often economically difficult. In this regard, preferential lending, state guarantees, export credit financing, as well as leasing of high-tech equipment play a key role, which allows to gradually transfer payments to the period of actual technology implementation. In international practice, credit support for technology transfer is implemented through: credit programs with compensation for part of the interest rates (through SBA and SBIR in the USA for small aerospace companies, export credit agencies (ECA)). These institutions issue loans under state guarantees for the purchase of licensed technologies and equipment, consortium loans provided by several banks for large projects in the field of space and aircraft construction. Examples include: Airbus financing through EU banks, targeted credit lines of IFIs (World Bank, EBRD, EIB) allocated for innovative dual-purpose projects.

In Ukraine, credit support for the transfer of technologies by ASC is constrained by the high cost of borrowed resources, limited credit history of enterprises in the sector and military instability. That is why the development of specialized credit programs with state support, participation in export credit financing programs by the EU is of paramount importance. In the case of creating conditions for attracting bank lending within clusters, risks can be distributed between several enterprises (Table 5).

Credit provision is a tool for attracting loan resources for high-tech projects characterized by a long payback cycle and high capital intensity. Among the main forms: preferential lending, state guarantees, export credit financing (ECA), consortium loans, equipment leasing and target loans from international financial organizations (World Bank, EBRD, EIB).

Table 5

Forms of credit support for technology transfer in the aerospace complex

Form of credit security	Purpose / appointment	Examples and features
Preferential lending	Reducing the cost of a loan for enterprises implementing new technologies	SBA and SBIR programs (USA), government credit lines for innovative startups
State guarantees	Reducing the credit risk of banks, attracting borrowed funds	Ukrainian government guarantees, EU programs for the development of high-tech sectors
Export credit financing	Financing the purchase of licenses and equipment abroad	Export-Import Bank (USA), Euler Hermes (Germany), UK Export Finance
Consortium loans	Financing large projects by involving several banks	Financing Airbus and large EU space projects
Equipment leasing	Allows to distribute the costs of technologies over the period of their implementation	Lease of high-tech equipment for the production of aircraft engines or space systems
International target loans	Attracting resources from international financial organizations	Programs to support innovative production and technology transfer of the World Bank, EBRD, EIB

Budgetary financing of ASC enterprises provides strategic programs for modernization of the industry, grant research and development of high-tech clusters. In international practice, this is implemented through special articles in the budgets of NASA, ESA and the US Department of Defense, which provide for financing technology transfer and commercialization of developments. In Ukraine, budgetary financing needs to be optimized and integrated with international innovation support programs.

The main areas of budgetary provision are: financing of R&D in the development of new aircraft engines, space systems and components of high-tech equipment; creation and support of innovation clusters and technology hubs. They are designed to ensure the joint use of infrastructure, laboratories and production sites. Grant funding and subsidies to support small and medium-sized enterprises in the process of implementing innovative solutions are important for the expansion of market relations in the ASC. Participation in EU programs (Horizon Europe, European Defence Fund) and other international funds that provide funding for technology transfer will contribute to the expansion of international cooperation.

International practice shows the effectiveness of budget funding in creating favorable conditions for technology transfer. For example, NASA and ESA form special budget items for Technology Transfer and Commercialization programs, which provide funding for both scientific developments and technology commercialization. Similar programs are implemented in Canada, France and Germany, where the state budget acts as a catalyst for the modernization of the aerospace industry.

In Ukraine, budgetary support for the transfer of technologies in the ASC requires a systematic approach and in-

tegration with other sources of financing, in particular credit and through public-private partnerships. Such a combination allows for the optimal distribution of financial risks, ensuring the sustainability of innovative projects and accelerating the introduction of modern technologies into the production processes of the aerospace complex.

Public-private partnership (PPP) in the aerospace sector is one of the key tools for attracting private investment to modernize the material and technical base and introduce advanced technologies. Through PPP, the state provides partial financial support, guarantees or preferential lending conditions, and the private sector invests capital in the creation of high-tech equipment, software and innovative production processes.

The main advantages of PPP in the context of technology transfer are: sharing of financial risks between the state and private investors; accelerated implementation of innovations by attracting flexible and high-tech private structures. Access to international resources in the form of grants, loans and investments through joint projects helps to increase the efficiency of cluster interaction by uniting enterprises, scientific institutions and financial structures into innovative ecosystems.

In the world, examples of successful PPPs in the aerospace industry are: joint programs of NASA and private companies (SpaceX, Blue Origin) for the development of new space technologies. The Airbus and Dassault Aviation projects within the European Aerospace Cluster are financed by both the state and private investors. A feature of innovation support within the framework of public-private partnership programs in Canada through the Ontario Aerospace Council is the financing of startups and small businesses at the initial stages of their operation.

In Ukraine, the development of PPP in the ASC field is at the stage of formation. The creation of an effective partnership system involves legislative regulation, the introduction of financial incentives, state guarantees and mechanisms for sharing infrastructure. The PPP implementation provides synergy between financial resources, cluster cooperation and technology transfer, which creates favorable conditions for the modernization of the aerospace industry and its integration into global technological chains.

The main goals of ASC modernization are: increasing the technical level of production; mastering promising types of aerospace technology; reducing the cycle from R&D to serial production; reducing energy and material intensity. Compliance with international technological and environmental standards (ICAO, ESA, NASA, ECSS, etc.) will contribute to ensuring the modernization of the industry through technical and economic processes of equipment renewal, introduction of robotic production lines, additive technologies, smart manufacturing, etc. The main types of enterprise modernization are: innovative and technological, organizational and managerial, and personnel. Innovative and technological modernization involves the creation and transfer of new materials, engines, control systems, and the use of dual-purpose space technologies. Organizational and managerial modernization is based on digital management systems, ERP, CRM, project approach, and cluster cooperation models. Personnel modernization aims to form highly qualified personnel, improve STEM competencies, and attract young scientists through partnerships with universities.

Management of innovation activities of aerospace enterprises has the following components: management of knowledge, resources and capabilities, management of technology transfer, management of relations between scientific and educational institutions and enterprises of the industry. Identification of these components allows to systematize various factors that, from the point of view of the flow of knowledge, contribute to the implementation of technological transfers in the aerospace sector, reflecting their efficiency and effectiveness, ability to absorb and open to innovations.

The integration of new digital technologies modernizes traditional practices in engineering and scientific fields. Nondestructive testing (NDT), or Nondestructive Evaluation (NDE) uses these technologies for inspection and monitoring of materials and structures [17]. The concepts of NDT 4.0 have specific application in the aerospace complex by introducing digital technologies throughout the work process, which will help reduce the time for preparing and conducting control measures, as well as increase the efficiency of management decisions based on their results. NDT 4.0 has significant potential for providing inspections during design, developing technology transfer models, monitoring feedback to the production process, and using data on the condition of structures throughout the life cycle of the innovation object.

5. 4. Leading world experience in financial, credit and budgetary support for the development of the aerospace complex

A generalization of world experience shows that despite significant public and private investments in research and development in the defense and space sectors (over 180 billion USD), investments in certain critical technologies remain consistently low or even decrease [18]. Without adequate funding for technology transfer in such areas as space engines, new generation materials (high-frequency, ultra-high entropy), the risk of innovation stagnation increases significantly.

According to OECD, the transfer and commercialization of space technologies have become an important source of innovation, growth and job creation not only in the space sector, but also in related sectors of the economy. However, public policymakers often do not have clear tools and assessments of the effectiveness of supporting such transfers, which reduces the effectiveness of public funding. Public and private funding is critically important for launching technology transfer. The introduction of partnerships, fiscal incentives (guarantees, tax breaks) and support structures can significantly increase the efficiency of the technology transfer process in the aerospace complex.

The use of foreign direct investment (FDI) is a key element in the development of national economies focused on sustainable development. In the case of the aerospace complex, security considerations limit FDI flows and the creation of multinational enterprises (MNEs) on a market basis. State administration bodies play an important role in ensuring the functioning of the industry through significant control over the structure, efficiency of procurement, regulatory aspects. Evaluating foreign experience, it should be noted that in countries where the aerospace industry is a leading export sector. public spending and fiscal policy significantly affect its development.

Aerospace development strategies should combine innovative tools, including the creation of state institutions to support their development. State scientific and technical institutions (SSTI) should take on and consolidate a proactive role in innovation management to transform the knowledge gained from achievements into relevant results for the indus-

trial base. Strategic management actions should be aimed at supporting the ecosystem of the sector and guided by the principle of entrepreneurship. The main tasks of an integrated approach to the process of technological innovation are to guarantee an architecture and organizational management that promote entrepreneurial behavior. Current trends are to ensure the connection with the strategy of technological innovation in the ecosystem to expand and facilitate interaction between its agents; create an attractive institutional environment for attracting innovations and disseminating the acquired knowledge.

The transfer of modern technologies in the aerospace complex plays an extremely important role and ensures an innovative breakthrough, since without targeted financing for the transfer of new technologies, the industry will not be able to move forward. The transfer of space technologies has an important macroeconomic impact by stimulating the development of related industries and creating additional economic value. However, it requires a balanced policy and the use of support instruments, since there is no single transfer model. Therefore, it is necessary to analyze financial mechanisms to form effective state regulatory mechanisms.

Clusters have significant potential for strengthening the innovative activity of enterprises in the aerospace complex, focused on attracting internal and external resources. They should provide an association of scientific institutions, industrial enterprises, startups and financial structures in order to accelerate the transfer of technologies and commercialization of high-tech developments. The cluster model allows to create a favorable environment for the exchange of knowledge, the implementation of cooperation projects and the implementation of joint programs for the modernization of the material and technical base. In the EU, the USA, Canada and China, aerospace clusters have become a key focus for implementing government technology transfer programs, attracting venture capital and implementing public-private partnerships. This confirms that the development of aerospace clusters is one of the strategically important tools for accelerating the innovative development of the industry.

Among the most famous global aerospace clusters, the following should be highlighted: Aerospace Valley (Toulouse, France), which unites more than 800 companies, research centers and universities, which actively cooperates with Airbus and ESA, forming an ecosystem for technology transfer [19]. Ontario Aerospace Council (Canada) is a cluster that includes manufacturers of aircraft engines, components and R&D centers with an emphasis on dual-purpose technologies and public-private financing [20]. The National Ukrainian Space Cluster / Dnipro Aerospace Cluster (Ukraine) [21] is being formed on the basis of enterprises of the State Enterprise "DB "Pivdenne", the State Enterprise " Production Association Southern Machine-Building Plant named after O. M. Makarov " and local startups. Its development requires increased state support and integration with international technology transfer programs.

The development of aerospace clusters is one of the strategic directions for accelerating innovation and modernization of the industry, as well as an important tool for attracting financial and credit resources and implementing budget support programs. Table 6 systematizes the experience of foreign budget sources / programs to support the aerospace complex during 2020–2025.

According to the NASA budget for 2022–2025, an increase in funding for technology transfer and commercialization programs for space technologies (NASA Technology Transfer Program, SBIR/STTR) is provided, which confirms the growing role of public funding in the modernization of the material and technical base of the aerospace complex [22]. Similar mechanisms are implemented through the ESA Technology Transfer Programme and the European Defense Fund (EDF), which creates an international trend for budgetary and credit support for technology transfer.

Table 6

Results of systematization of the experience of European-American budget sources / programs to support the aerospace complex during 2020—2025

Organization / structure	Document / program	Funding object	Period
NASA (USA)	NASA Budget Justification (FY2022–FY2025)	R&D, Space Technology Transfer Program, Commercialization Initiatives, Small Business Innovation Research (SBIR)	2021–2025
European Space Agency (ESA)	ESA Technology Transfer Programme (TTP) Budget	Space technology transfer programs in civil sectors, financing of pilot projects	2020–2025
Department of Defense USA (DoD)	Defense Innovation Unit Budget, Technology Transfer & Transition Program (T2)	Modernization of defense aerospace systems. joint research with the private sector	2020–2024
European Defense Fund (EDF – EU)	EDF Budget Regulation (2021–2027)	Co-financing of R&D for aerospace & defense, stimulating technology transfer between EU countries	2021–2027
Federal Aviation Administration (FAA)	FAA Technology Transfer Program Report	Civil aviation, innovations, modernization of air navigation systems. use of R&D	2020–2024

Since most scientific and technical developments in the field of aerospace systems have a high capital intensity and level of technological risks, the private sector is unable to provide adequate financing for R&D and technology transfer without state participation. That is why the budgets of NASA, ESA, EDF and DoD for 2020–2025 contain targeted programs for financial and credit and grant support for the transfer of modern technologies to the real sector, which confirms the extreme relevance of the researched issues [23].

International experience shows a constant growth in the role of public funding in stimulating innovation in the space and aviation sectors. Thus, in the NASA budget for 2022–2025, separate programs are aimed at the commercialization and transfer of space technologies (Technology Transfer Program, SBIR/STTR). The European Space Agency (ESA) is implementing a long-term Technology Transfer Program, within which funding is provided for pilot projects for the integration of innovations into real sector enterprises [24]. Similar mechanisms operate within the framework of the European Defense Fund (EDF) and the budgets of the US Department of Defense, which confirms the relevance of public participation in financing these processes.

For example, a study of CRADAs (Cooperative Research and Development Agreements) for the US Air Force involves their analysis through the prism of Public Value Governance,

although not specifically about financing, but about technology transfer mechanisms.

The leading leader in the dissemination of technology transfer is NASA. The institution implements the following projects:

– Spin-off Technologies, which relate to small business technology transfer innovation programs with the participation of US government funding, coordinated by the Small Business Administration SBIR (Small Business Innovation Research); as well as the tax treaty provision that allows signatory countries to impose additional tax obligations on certain STTR (Subject-to-Tax Rule) payments; patent licensing, technical assistance, etc.;

– TechPort is a system for tracking R&D (Research and Development) including data on budgets, status, scope and potential benefits for the agency, industry and society.

In the modern period, the economic terms "spin-in" and "spin-out" are used in the field of technology transfer, which describe related supply chains and innovation processes. Spin-in involves the purchase or investment in an independent startup that has already been founded on the basis of employee intellectual property, but does not belong to the company at the initial stage, and may later be acquired. Spin-out can be interpreted as the process of obtaining the status of independence of part of the company, as well as a type of corporate restructuring, when it divides its assets or divisions to increase efficiency and attractiveness for investors. Spin-off / spin-out companies are created on the basis of NMA (usually patents) of commercialization of scientific developments.

The Aerospace sector occupies a leading position in the global technology transfer market – especially in advanced manufacturing processes, innovative materials, avionics and is a key segment in global technology transfer markets.

5. 5. Diagnostics of problems of modernization of the aerospace complex based on technology transfer and ways to solve them

The main directions of technology transfer in the aerospace complex of Ukraine are: permission for the transfer of state defense sector technologies to private manufacturers; implementation of the BRAVE1 initiative as a technology park for defense technologies and dual-use technologies. It is important to create government clusters that coordinate interagency cooperation; implement initiatives designed to stimulate innovation, unite startups and companies; ensure cooperation with international R&D platforms. The Horizon Europe office in Ukraine, opened at the end of 2023, provides Ukrainian scientists and entrepreneurs with access to grants, technical support and networks with European partners. With the participation of the European Space Agency, mechanisms for interaction between the ASC and the state are being worked out through STCU (Science and Technology Centre in Ukraine), including by organizing seminars of the "From Science to Business" type to exchange experience in the field of technology transfer.

An example of the successful functioning of cluster cooperation in Ukraine, the transfer of knowledge, competencies and modern technologies to the aerospace industry is the activity of Progresstech Ukraine. It has been cooperating with Boeing for more than 10 years, developing engineering and IT solutions for enterprises in the high-tech sector of the economy [25]. The company has a professional team of about 1,000 engineers and programmers and is the largest provider of services for the global aerospace technology market in Eastern and Central Europe. Education and training of specialists play an important role in the technology transfer system in the aerospace industry. The UADUT Clustering (Aerospace & Defence Academy) project is a transdisciplinary academy for training engineers in the field of aviation and defence [26]. In Ukraine, such powerful educational centers as the Kyiv Aviation Institute and the Kharkiv Aviation Institute remain key sources of personnel and scientific and technological developments for the aerospace industry. International defense technology transfer is implemented by AeroVironment (USA) [27] and Czechoslovak Group (CSG) [28], which transfer technologies and documentation for the production of ammunition or drones in Ukraine as dual-use products. The programs of the European Space Agency STCU (Science and Technology Centre in Ukraine) / ESA (European Space Agency) stimulate the transfer of research results to the civilian sector.

The following entities contribute to the transfer of technology in the ASC of Ukraine: the government of Ukraine adopts legislative decisions on the transfer of documentation, financing BRAVE1; international contractors implementing the Horizon Europe, STCU, EU, NATO programs. The main participants of the Progresstech, Aerospace & Defence Academy technology clusters are: direct investors – Boeing, AeroVironment, CSG; educational institutions – KAI, KHAI, which have the necessary human and scientific base.

BRAVE1 is a platform for financing defense technologies and startups. The transfer of state technologies to private manufacturers involves granting permission to use Ukroboronprom JSC documentation. Progresstech Ukraine-Boeing cooperation is based on engineering outsourcing. The Ukrainian Horizon Europe project promotes the participation of universities and enterprises in international consortia. The joint projects AeroVironment and CSG are focused on the localization of the production of unmanned aerial vehicles and ammunition with the transfer of technologies.

Analytical data on the financing of the State Space Agency of Ukraine from the State Budget of Ukraine under the program classification code 6380000 are presented in Table 7 according to the State Budget Web Portal for Citizens [29].

During the analyzed period of 2018–2025, there was a chronic underfunding of the activities of the State Space Agency of Ukraine with a minimum value of 70.27% in 2024. During 2018–2025, the amount of funding in the national currency decreased from 2,383,951.4 thousand UAH to 1,032,198.6 thousand UAH, or by 56.7%, and in foreign currency – from 86,125.4 thousand USD to 24,729.2 thousand UAH, or by 71.3%. That is, at a faster pace due to the depreciation of the national currency.

The dynamics of funding volumes is described by a parabola with upward branches (Fig. 1), since its maximum value was observed in 2018 (2384.0 million UAH), in 2019 there was a sharp reduction to 668.1 million UAH.

Over the next two years, there was an increase to 1,301.1 million UAH 2022 became another year of a sharp decrease in funding to 876.3 million UAH due to the full-scale invasion of the Russian Federation into Ukraine. After two years of growth to 1,185.9 million UAH by the end of 2025, a reduction in funding for the State Space Agency of Ukraine to 1,032.2 million UAH is expected.

The general trends in technology transfer in the ASC of Ukraine during 2019–2025 are an increase in the need for modernization of the material and technical base due to the

war and integration into the global aerospace technology market. The prerequisites for a successful transition from a state monopoly to a cluster model are the combination of state and private enterprises, scientific institutions and universities; active involvement of international programs (EU, NATO, ESA, Horizon Europe).

Table 8 formalizes the proposed "5M" structure for technology transfer in the aerospace complex.

For effective technology transfer in the ASC, it is important to simultaneously ensure a balance of all five "Ms": Machines, Manpower, Materials, Methods, Money. The insufficiency of at least one element (for example, financing or staffing) levels the effect of the others. The BRAVE1 (Ukraine) programs and Horizon Europe grants are important.

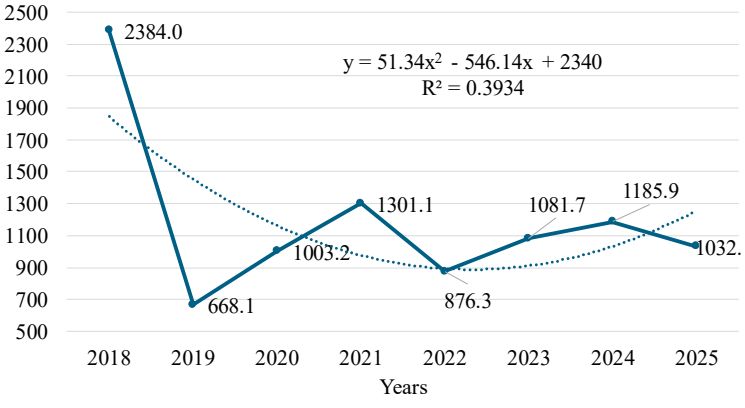

Fig. 1. Formalization of the dynamics of financing of the State Space Agency of Ukraine from the State Budget of Ukraine by program classification code 6380000, million UAH

Table 7

Analytical data on the financing of the State Space Agency of Ukraine from the State Budget of Ukraine under the program classification code 6380000

Year	Funding volume			Percentage of plan implementation, %
	Planned	Planned adjusted	Actual	
Thousand UAH				
2018	2,450,033.2	2,481,812.0	2,383,951.4	96.05
2019	659,599.3	675,454	668,070.2	98.90
2020	882,223.1	1,041,741	1,003,222	96.30
2021	1,122,697.3	1,315,421	1,301,138	98.91
2022	1,319,058.6	978,695.3	876,307	89.53
2023	1,169,968	1,192,248	1,081,654	90.72
2024	1623676.4	1687434	1,185,920	70.27
2025 (1st half of the year)	1,091,710.8	1,200,650.5	516,099.3	42.98
2025 (extrapolation)	2,183,421.6	2,401,301	1,032,198.6	85.96
Growth rate, times	0.891	0.968	0.433	0.895
Thousand USD				
2018	88,512.8	89,660.8	86,125.4	96.05
2019	27,854.7	28,524.2	28,212.4	98.90
2020	31,207.0	36,849.7	35,487.2	96.30
2021	41,169.7	48,236.9	47,713.2	98.91
2022	36,079.3	26,769.6	23,969.0	89.53
2023	30,804.8	31,391.5	28,479.6	90.72
2024	38,622.2	40,138.8	28,209.3	70.27
2025 (1st half of the year)	26,217.8	28,834.1	12,394.3	42.98
2025 (extrapolation)	52,310.1	57,530.0	24,729.2	85.96
Growth rate, times	0.591	0.642	0.287	0.895

Table 8

Proposed "5M" structure for technology transfer in the aerospace complex

No.	Structure elements	Objects/entities	Contents
1	Machines	Aerospace equipment, production lines, test benches, spacecraft	Example: Transfer of modern technologies for the production of drones or rocket engines to Ukraine from international partners
2	Manpower	Qualified engineers, scientists, designers, operators	Retraining and integration of Ukrainian specialists into international programs (ESA, Boeing, Airbus, Horizon Europe)
3	Materials	Access to new materials and their processing technologies: composites, superalloys, nanostructures, 3D printing for aerospace	Transfer includes not only procurement, but also production localization technology
4	Methods	Innovative processes: CAD/CAE/PLM systems, digital twins, lean manufacturing, automation and robotics, transfer of know-how and patents	Implementation of digital design technologies for the integration of Ukrainian enterprises into global Airbus or Boeing chains
5	Money	Sources of financing: State budget of Ukraine, loans, venture capital, EU grants, public-private partnerships	Technology transfer requires financial adaptation tools: preferential lending, R&D subsidies, guarantees for private investors

6. Discussion of the results of financial, credit and budgetary support for the modernization of the ASC based on technology transfer

The results of the work allowed to confirm the main hypothesis about the dependence of the effectiveness of financial, credit and budgetary support for enterprises of the aerospace complex of Ukraine on the volume of available resources, their quality, structuring, and orientation towards innovative areas, in particular through mechanisms of technology transfer, public-private partnership and integration into international programs.

The dynamics of the volume of investments in intangible assets and capital investments in the ASC are summarized, their structure and level are analyzed (Table 1). The results obtained are used to identify patterns in the dynamics of the cost of software and databases, as well as intangible assets based on trend analysis, which are formalized by polynomial functions. They describe processes that grow (1) or decline with acceleration (2). The results of the analysis of the dynamics and structure of capital investments in the ASC (Table 2) establish their chaotic nature, as well as the presence of significant structural changes associated with the reduction in the share of passenger air transport due to an increase in the specific weight of aerospace transport. The assessment of the balances of funds under loans granted to business entities of the aerospace complex of Ukraine as of July 1, 2025 and their structure (Table 3) shows that, according to the results of the horizontal analysis, the specific weight of the national currency slightly exceeds the foreign one. The most active activity in lending in foreign currency is demonstrated by large enterprises, the least by microenterprises. According to the results of the analysis of the amount of exposure at risk on loans provided to economic entities of the ASC in Ukraine (Table 4), it is shown that the greatest credit risk in foreign currency is borne by large enterprises, in national currency by medium-sized enterprises. The generalization of the experience of credit support for technology transfer in the aerospace complex (Table 5) made it possible to determine its main forms. The results of the systematization of the experience of foreign budget sources / programs to support the aerospace complex during 2020–2025 (Table 6) provide guidelines for adapting the allocated instruments to the institutional conditions of Ukraine. Analytical data on the budget support of the State Space Agency of Ukraine (Table 7) made it possible to establish its chronic underfinancing of its activities. The dynamics of its financing from the State Budget of Ukraine (Fig. 1) is formalized by a parabola with upward branches, which indicates a gradual improvement in the situation after a long decline. The proposed structure of "5M" for technology transfer in the aerospace complex (Table 8) assumes the unity of the following factors: Machines, Manpower, Materials, Methods, Money.

The proposed approaches to diagnosing the problems of innovative development of the aerospace complex and the obtained results differ significantly from existing studies, the results of which are presented, in particular, in the works [2, 6, 7, 9, 17]. Their developments and recommendations are dedicated to economies and aerospace complexes built on high technological structures, which do not experience a lack of financial, credit and budgetary support for strategic innovative development. The institutional features of Ukraine are a source of financial, technical, technological, and innovative limitations to the development of domestic ASCs. Works [3, 11, 12] more adequately reflect the Ukrainian realities of the ASC functioning, but the mentioned study has a number of advantages, including: comprehensive use of theoretical hypotheses (lack of resources, external dependence on foreign funding and international programs; institutional inefficiency of financial resources, military factor, innovative breakthrough) and substantiation of directions for their practical use.

Recommendations have been developed for Ukraine's transition to a systemic technology transfer model that combines public funding, private investment, and international assistance. Unlike existing approaches, the proposed financial and credit mechanisms are based on grants (EU, ESA), public funding (BRAVE1, defense budget), venture capital investments, and a cluster approach. The evidence base uses the results of a statistical study of financing, lending, investing, and budgeting of the ASC. However, the limitations of the study are the conditions of martial law, which provide for the temporary cessation of the use of airspace for air transport. This narrows the scope of application of the proposed solutions, reduces their stability in the face of changing influencing factors, especially in the face of decreasing foreign policy and economic support for Ukraine and its ASC. The disadvantages of this study include insufficient consideration of the factors of the lack of launch sites for spacecraft in Ukraine, which can be eliminated within the framework of the implementation of public-private programs for the post-war recovery of the national economy. There are also shortcomings in information provision related to the confidentiality of information on the ASC functioning. This is clearly evidenced by Table 2, where gaps in data on capital investments were eliminated by averaging, elimination, and correction coefficients. There is also a lack of open information on international technology transfer by type of ASC economic activity.

The development of this study consists in substantiating proposals for institutional support of the aerospace complex in terms of implementing priority measures related to the needs of the military economy and defense.

7. Conclusions

1. It is proven that in modern conditions the modernization of the aerospace industry is closely related to the expansion of international cooperation, integration into global production chains and the development of technology transfer mechanisms. It is found that the ASC modernization is a technical process and a strategic direction of national economic policy aimed at preserving the scientific and technical potential of the state, strengthening defense capabilities and increasing the export potential of highly intelligent products. It is shown that financial support for technology transfer in the ASC is a key prerequisite for the modernization of the industry. A comprehensive combination of budget and credit financing allows forming the conditions under which the latest technologies can effectively transfer from scientific institutions to industrial production.

2. The principles of an effective credit support system are established, which should be built on a combination of bank capital, state guarantees, international development funds and cluster co-financing. The above will allow creating a financial basis for the implementation of technology transfer in the aerospace complex and will ensure long-term modern-

ization of the industry. The main forms of credit support for the aerospace complex are systematized: preferential lending, state guarantees, export credit financing, consortium loans, equipment leasing, international target loans.

3. It is substantiated that budgetary support for technology transfer in the aerospace complex is a key element of the state policy of modernization of the industry, as it allows financing strategic programs, R&D, creating innovative clusters and building scientific and technical infrastructure. In the context of the high capital intensity of aerospace projects, budgetary financing provides a stable flow of resources for the implementation of long-term innovation programs. which cannot be fully covered by private investments.

4. The European and American experience of financial, credit and budgetary support for the development of the aerospace complex of the leading countries of the world is summarized. Its main forms and methods are: R&D, space technology transfer programs in the defense and private sectors, commercialization initiatives, innovation research for small businesses, financing of pilot projects, modernization of defense aerospace systems. joint research with the private sector, etc.

5. According to the results of statistical research, the achievements and problems of modernization of the national economy and the aerospace complex of Ukraine based on the transfer of modern technologies during 2015–2023 were diagnosed. The main achievements were identified as: an increase in the cost of investments in intangible assets; an increase in the volume of capital investments in cargo aerospace transport. The main problems of modernization of the national economy and the ASC of Ukraine were identified as a reduction in the volume of investment in commercial designation rights, industrial property objects, copyright compared to investment in software. It is statistically shown that the greatest opportunities for financing technology transfer through borrowed funds are for large, micro and small enterprises of the ASC. Ways are proposed to solve the problems of transferring modern technologies based on improving the financing of researchers from the state budget, international funds, private capital, investors, grant programs, etc.; expanding tax benefits, etc. The above recommendations will ensure the fastest possible information and effective communication between scientists and representatives of business organizations, as well as the formation of a modern technology transfer infrastructure.

Conflict of interest

The authors declare that they have no conflict of interest regarding this study, including financial, personal, authorship or other, which could affect the study and its results presented in this article.

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Data availability

The manuscript has related data in the data repository.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

References

1. Padilla Bejarano, J. B., Zartha Sossa, J. W., Ocampo-López, C., Ramírez-Carmona, M. (2023). University Technology Transfer from a Knowledge-Flow Approach – Systematic Literature Review. Sustainability, 15 (8), 6550. https://doi.org/10.3390/su15086550
2. Petroni, G., Venturini, K., Santini, S. (2010). Space technology transfer policies: Learning from scientific satellite case studies. Space Policy, 26 (1), 39–52. https://doi.org/10.1016/j.spacepol.2009.11.004
3. Chervinska, L., Kalina, I., Chervinska, T., Milenkyi, V., Grishchenko, A., Khorosheniuk, A. (2025). Technology transfer in the system of innovation development: challenges and opportunities. Technology Audit and Production Reserves, 2 (4 (82)), 80–87. https://doi.org/
4. 10.15587/2706-5448.2025.327378
5. Harris, D., Harris, F. J. (2004). Evaluating the transfer of technology between application domains: a critical evaluation of the human component in the system. Technology in Society, 26 (4), 551–565. https://doi.org/10.1016/j.techsoc.2004.08.003
6. Speldekamp, D., Knoben, J., Saka-Helmhout, A. (2020). Clusters and firm-level innovation: A configurational analysis of agglomeration, network and institutional advantages in European aerospace. Research Policy, 49 (3), 103921. https://doi.org/10.1016/j.respol.2020.103921
7. Brandão Neto, N., Leite, B. R. de A., Melo, F. C. L. de. (2023). Model for Strategic Management of Technological Innovation in Science and Technology Institutions in the Brazilian Aerospace Sector: A Proposal. Journal of Aerospace Technology and Management, 15. https://doi.org/10.1590/jatm.v15.1313
8. Landoni, M., ogilvie, dt. (2019). Convergence of innovation policies in the European aerospace industry (1960–2000). Technological Forecasting and Social Change, 147, 174–184. https://doi.org/10.1016/j.techfore.2019.07.007
9. Biggiero, L., Angelini, P. P. (2015). Hunting scale-free properties in R&D collaboration networks: Self-organization, power-law and policy issues in the European aerospace research area. Technological Forecasting and Social Change, 94, 21–43. https://doi.org/10.1016/j.techfore.2014.04.009
10. Zervos, V. (2019). Strategic Microeconomic Considerations of Macroeconomic Analysis: Fiscal, Trade and Security Impacts of Aerospace and Defence. Defence and Peace Economics, 32 (5), 621–634. https://doi.org/10.1080/10242694.2019.1641933
11. Kosova, T., Smerichevskyi, S., Antypenko, N., Mykhalchenko, O., Raicheva, L. (2023). Innovative and financial modernization of transportation system based on international technology transfer. Eastern-European Journal of Enterprise Technologies, 5 (13 (125)), 47–56. https://doi.org/10.15587/1729-4061.2023.289101

12. Petrovskyi, O., Petrovska, S. (2015). Transfer of high technologies in aviation activity. Problemy systemnoho pidkhodu v ekonomitsi, 51, 198–202. Available at: http://nbuv.gov.ua/UJRN/PSPE_print_2015_51_35
13. Novikov, E. (2018). Legal Forms Activity of Technology Transfer Network on Example in Aerospace Industry. Advanced Space Law, 1, 74–83. https://doi.org/10.29202/asl/2018/1/9
14. Statystychnyi shchorichnyk Ukrainy – 2023 (2024). Derzhavna sluzhba statystyky Ukrainy. Available at: https://ukrstat.gov.ua/druk/publicat/kat_u/2023/zb/11/year_23_u.pdf
15. Transport of Ukraine. State Statistics Service of Ukraine. Available at: https://www.ukrstat.gov.ua/druk/publicat/kat_u/2024/zb/10/zb_Trans_23.pdf
16. Naukovo-analitychna dopovid «Naukova, naukovo-tekhnichna ta innovatsiyna diyalnist v Ukraini u 2023 rotsi» (2024). Kyiv. Available at: https://mon.gov.ua/static-objects/mon/sites/1/nauka/informatsiyno-analitychni/2024/05.08.2024/Naukovo-analitychna.dopovid-Naukova.naukovo-tekhnichna.ta.innovatsiyna.diyalnist.v.Ukrayini.u.2023.rotsi-05.08.2024.pdf
17. Rozpodil kredytiv, nadanykh subiektam hospodariuvannia v natsionalniy ta inozemniy valiutakh za rozmirom subiekta hospodariuvannia ta vydamy ekonomichnoi diyalnosti, shcho klasyfikuiutsia za rozdilamy, z nykh defoltnykh vidpovidno do Polozhennia No. 351 ta nepratsiuiuchykh vidpovidno do Polozhennia No. 97 stanom na 1 lypnia 2025 roku. Available at: https://bank.gov.ua/files/stat/Loans_MSE_KVED_2025-07-01.xlsx
18. Gregory, E., Juarez, P., Leckey, C. (2025). NDE 4.0 in Aerospace. Handbook of Nondestructive Evaluation 4.0, 1643–1685. https://doi.org/10.1007/978-3-031-84477-5_67
19. Space technology transfers and their commercialisation (2021). In OECD Science, Technology and Industry Policy Papers. Organisation for Economic Co-Operation and Development (OECD). https://doi.org/10.1787/0e78ff9f-en
20. Aerospace Valley. Available at: https://www.aerospace-valley.com/en
21. Ontario Aerospace Council. Available at: https://theoac.ca
22. All-Ukrainian Association of Innovative Space Clusters. Available at: https://clusteratlas.org.ua/en/clusters/ua-spacetech-supercluster
23. NASA Technology Transfer Program. Available at: https://technology.nasa.gov
24. Technology Transfer (T2) Program. Available at: https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/activities/ttp
25. The Office of Technology Transfer. Available at: https://aerospace.org/techtransfer
26. Prohrestekh-Ukraina. Available at: https://www.progresstech.ua/
27. Proiekty Klasteru. Ukrainskyi klaster podviynykh tekhnolohiy. Available at: https://uadutcluster.tech/programi-ta-proiekti
28. AeroVironment. Available at: https://www.avinc.com/
29. CSG. Czechoslovak Group. Available at: https://czechoslovakgroup.com/en
30. Ministerstvo finansiv Ukrainy. Available at: https://openbudget.gov.ua/national-budget/expenses?class=program